

WHAT IS CLAIMED IS:

- 1 1. A switching element comprising:
 - 2 a first actuator enabled for physical movement to selectively
 - 3 manipulate movement of a fluid within a gap; and
 - 4 a first optical waveguide and a second optical waveguide that
 - 5 intersect said gap such that optical communication from said first waveguide
 - 6 to said second waveguide is determined by a presence of said fluid within
 - 7 said gap, said fluid being selectively manipulated in response to said physical
 - 8 movement of said first actuator.
- 1 2. The switching element of claim 1 wherein said first actuator is con-
2 figured for reciprocating movement and is positioned to determine fluidic
3 communication within said gap, said fluid being selectively displaced when
4 said first actuator is moved between first and second positions.
- 1 3. The switching element of claim 2 wherein said reciprocating movement
2 is made in response to applications of an input voltage, said first actuator
3 being disposed to achieve volumetric variations with said reciprocating move-
4 ment.
- 1 4. The switching element of claim 2 wherein said gap is defined by a
2 trench having walls for containing said fluid within said gap, said first actuator
3 positioned along one of said walls for displacing said fluid within said gap.
- 1 5. The switching element of claim 4 wherein said first actuator is a piezo-
2 electrically driven actuator and includes a membrane that is configured to
3 switch between an outward position and an inward position in relation to said
4 wall.
- 1 6. The switching element of claim 5 wherein said membrane includes a
2 stress-biased lead zirconia titanate (PZT) material.

1 7. The switching element of claim 5 wherein said membrane is coupled to
2 a first electrode on a first side and a second electrode on a second side, said
3 first side and said second side being on opposite sides of said membrane,
4 said first electrode being coupled to a voltage source by a first electrical
5 connection and said second electrode being coupled to said voltage source
6 by a second electrical connection.

1 8. The switching element of claim 7 wherein said first electrical connec-
2 tion is provided on a side of said membrane opposite to said second electrical
3 connection.

1 9. The switching element of claim 7 wherein said first electrical connec-
2 tion is provided on a same side of said membrane as said second electrical
3 connection, said first electrical connection being coupled to said first electrode
4 by a conductor.

1 10. The switching element of claim 1 wherein said fluid includes at least
2 one of a liquid and a gas, said liquid having an index of refraction similar to an
3 index of refraction of said first and second optical waveguides.

1 11. The switching element of claim 10 wherein said gas is one of an inert
2 gas and a combination of inert gases, said gas being at least one of nitrogen,
3 xenon, krypton, argon, neon, helium, carbon dioxide, and sulfur hexafluoride.

1 12. The switching element of claim 2 further comprising a second actuator,
2 said second actuator and said first actuator being on opposing sides of said
3 gap, wherein said second actuator is in fluidic communication with said gap,
4 said fluid being selectively displaced when said second actuator is activated
5 for said reciprocating movement.

1 13. The switching element of claim 1 wherein said first and second
2 waveguides are in optical communication when said fluid is present within
3 said gap, said switching element further comprising a third optical waveguide
4 intersecting said gap such that said first and third waveguides are in optical
5 communication when said fluid is absent from said gap.

1 14. An optical switch comprising:
2 a first light-transmitting waveguide and a second light-
3 transmitting waveguide having ends at an intersecting region, wherein optical
4 transmission between said first and second waveguides is determined by a
5 presence of a fluid within said intersecting region, said intersecting region
6 being a portion of a trench having a plurality of surfaces for accommodating
7 said fluid; and
8 a first electrically movable member in operative communication
9 with said intersecting region via said fluid, said first electrically movable
10 member being configured to move between a plurality of predetermined
11 orientations for displacing said fluid relative to said intersecting region.

1 15. The optical switch of claim 14 wherein said first electrically movable
2 member is positioned along one of said surfaces of said trench, said first
3 electrically movable member being configured to move among a convex
4 orientation, a concave orientation, and a relaxed orientation with respect to
5 said one surface, said relaxed orientation being one in which a location of
6 said first electrically movable member is generally aligned with an imaginary
7 surface that extends along said one surface.

1 16. The optical switch of claim 15 wherein said first electrically movable
2 member is configured to move between a first orientation and a second
3 orientation, said first and second orientations being separate ones of said
4 convex, concave and relaxed orientations.

1 17. The optical switch of claim 15 wherein said convex orientation
2 displaces said fluid in a direction away from said first electrically movable
3 member and said concave orientation enables said fluid to flow in a direction
4 toward said first electrically movable member.

1 18. The optical switch of claim 15 wherein said first electrically movable
2 member is a piezoelectric membrane in which an application of an electric
3 potential displaces said piezoelectric membrane to one of said convex,
4 concave and relaxed orientations.

1 19. The optical switch of claim 14 wherein said fluid includes a first bubble
2 and a second bubble disposed in said trench, said first bubble being selec-
3 tively displaced into said intersecting region when said first electrically
4 movable member is in one of said predetermined orientations, said first and
5 second bubbles being compressed when said first bubble is at said intersect-
6 ing region.

1 20. The optical switch of claim 14 further comprising a second electrically
2 movable member that is at an opposite side of said intersecting region from
3 said first electrically movable member, said second electrically movable
4 member being in operative communication with said intersecting region and
5 being configured to move between one of said predetermined orientations for
6 displacing said fluid relative to said intersecting region.

1 21. The optical switch of claim 20 wherein said fluid includes a bubble
2 disposed in said trench, said bubble being selectively displaced into said
3 intersecting region when said first electrically movable member is in a first
4 predetermined orientation and said second electrically movable member is
5 in a second predetermined orientation, said first and second predetermined
6 orientations being dissimilar orientations.

1 22. A method for manipulating optical communication in an optical switch
2 comprising:
3 providing an input waveguide and an output waveguide;
4 providing a trench at an intersecting gap of said input and output
5 waveguides;
6 receiving an optical signal at said input waveguide;
7 enabling a piezoelectric actuator to switch between a plurality of
8 configurations for displacing a fluid within said intersecting gap such that said
9 optical communication from said input waveguide to said output waveguide is
10 dependent upon a presence of said fluid within said intersecting gap; and
11 transmitting said optical signal from said input waveguide to said
12 output waveguide.

1 23. The method of claim 22 wherein said step of enabling includes manip-
2 ulating said piezoelectric actuator to switch among an outward configuration,
3 an inward configuration and a flat configuration with respect to a surface of
4 said trench, said piezoelectric actuator being in fluidic communication with
5 said intersecting gap such that said fluid is displaced relative to said intersect-
6 ing gap in response to said piezoelectric actuator being displaced to one of
7 said outward, inward and flat configurations.

1 24. The method of claim 23 wherein said step of manipulating includes
2 providing a piezoelectrically-driven membrane to switch among one of said
3 outward, inward and flat configurations in response to voltage inputs.

1 25. A method for operating an optical switch comprising:
2 piezoelectrically actuating a first membrane to manipulate a
3 change in volume of a fluid container such that a fluid disposed within said
4 fluid container moves between a coupling position in which light from a first
5 waveguide is received by a second waveguide and a noncoupling position in
6 which light from a first waveguide is not received by said second waveguide.

1 26. The method of claim 25 further comprising reversing said movement of
2 said fluid by piezoelectrically actuating said first membrane, resulting in a
3 reversal of said change in said volume.

1 27. The method of claim 25 further comprising reversing said movement of
2 said fluid by piezoelectrically actuating a second membrane.

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